NAMIBIAN VIBRATION CONSULTANTS

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Environmental Noise Report

PROPOSED INFRASTRUCTURE AND OPEN PIT EXPANSION AT RÖSSING URANIUM MINE

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EXECUTIVE SUMMARY

A new open pit adjacent to the existing open pit and two significant expansions to the existing fixed infrastructure of the mine are proposed in an area which has the generally low ambient noise levels typical of unoccupied rural environments. The investigation's purpose was to estimate any potential noise impact of the proposed expansions on the existing ambient noise climate in the surrounding area. This was achieved by measuring and modeling the existing ambient noise levels around the site as well as the noise of current operations at the mine, jn order to obtain the current baseline situation. A comparison was then made with the modeled future situation, including the new SK4 open pit operations and the acid plant and ore sorter, to determine the change in noise levels and the subsequent environmental noise impact to be expected of the proposed expansion.

Fifteen noise measurement positions on or near the mining concession boundaries and two at remote dwellings, were chosen as representative positions to assess how the mine expansion could impact on possible affected parties. In the absence of applicable Namibian national noise standards, all measurements were carried out in accordance with the relevant South African National Standards (SANS) Codes of practice, and as required by the regulations of the DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM, RSA.

The expected response from the local community to the noise impact, i.e. any increase of predicted operational noise over the original ambient noise, is primarily based on the relevant SANS document, and expressed in terms of the effects of impact, on a scale of 'NONE' to 'VERY HIGH'. This report is an overall assessment designed to predict the collective response of a noise-exposed population and therefore the impact the operation is likely to have on them, and is based on measured and predicted equivalent continuous noise levels according to the relevant SANS code of practice.

The daytime noise impact is generally rated as NONE to VERY LOW and the night-time noise impact is generally rated as NONE to LOW. The impact at some of the surrounding residences, in the worst case of the noisiest operations being at their closest to those dwellings during part of the lifetime of the mine expansion, especially where blasting noise is concerned, is rated as VERY LOW during daytime and LOW during night-time operations. Methods of mitigation, including barriers, operational and administrative procedures, plant maintenance, and on-site monitoring to ensure that any agreements are adhered to, are discussed.

The distance of the property boundaries from the open pit and the distance to the nearest dwellings is sufficient to ensure that ground vibration has reduced to levels unlikely to cause even cosmetic damage to these dwellings.

1. PURPOSE OF THE INVESTIGATION AND TERMS OF REFERENCE

A second open pit mining operation is proposed at a rural site adjacent to the existing open pit as well as expansions of the surface treatment plant to include new acid and ore sorter plants which can be expected to increase the noise on the site, especially in the vicinity of these plants. The area is remote from dwellings and has the generally low ambient noise levels typical of sparsely occupied rural environments. The investigation's purpose was to estimate any potential noise impact of the proposed mine expansion on the existing ambient noise climate in the surrounding area. This was achieved by measuring the existing ambient noise levels around the site as well as the noise of existing operations at the open pit and surface treatment plant, and comparing these with the post expansion predicted noise values obtained from the noise modeling program.

1.1. Construction phase

Construction activities associated with the new open pit infrastructure are similar to the subsequent mining activities and therefore unlikely to increase the noise level by more than that experienced for the operational phase. The construction of the acid plant and ore sorter are likely to take place over an extended period (greater than a year) and are therefore considered separately.

1.2. Operational phase

SK4 open pit

The assessment of this phase is one of the three primary purposes of this report. As far as the mining activities are concerned, the initial limited period of above-ground activities associated with the SK4 open pit pioneering work will be the worst case scenario, as there is direct line of site to these activities from some remote areas and there will therefore be no natural noise screening by the pit walls themselves until the pit reaches a depth at which the noise producing activities such as drilling and loading are removed from sight. Thereafter, noise from pit activities reduces steadily as the depth of the pit increases and only surface transport from the pit to the tipping area of the treatment plant and the treatment plant itself contribute significantly to the noise perceived at remote locations.

Acid Plant

The new acid plant is to be placed on an existing storage area on the northern extremity of the current area of the plant. In this position the town of Arandis is well protected by the natural barrier of the ridge to the north, which provides significant noise attenuation of the majority of the noise sources on the acid plant, excluding the top of the stack which may be visible from some remote areas.

Ore sorters

The bank of ore sorters is placed between the stockpile and the crusher area parallel to the existing conveyer to the crushers. This area is also well protected by the natural contours of the land which form a natural noise barrier in the direction of Arandis.

1.3. Decommissioning and closure phase

There may be significant noise impacts associated with the dismantling of the existing decommissioned damaged acid plant and the ultimate and removal of the structures of the entire treatment plant during the decommissioning phase of the site. This impact is likely to be of a short duration.

1.4. Possible residual and latent impacts

No residual or latent impacts expected.

2. INVESTIGATIVE METHODOLOGY

2.1. Introduction

The proposed mining area is situated in an unoccupied rural environment, with typically low levels of noise, dominated by the natural sounds of rustling vegetation, wildlife, but also existing mine-influenced sounds such as traffic, generated by current mine activity, which is already significant. Therefore it is to be expected that the noise from the suggested expansion in operations, using high-powered machinery, blasting, and other noisy procedures, could potentially have an impact on the surrounding area. In order to be able to assess both the quantitative and geographical extent of the potential impact, it is necessary to have baseline data in the form of existing ambient noise levels at the site and identified affected parties. These can then be compared to the noise levels predicted to be generated by the operation of the mine expansion. The extent of community response can then be assessed according to relevant national and international standards which take into account sociological factors as well as the estimated change in noise climate.

2.2 Ambient Noise Measurements At The Proposed Site

The existing ambient noise levels were measured over sampling periods of ten minutes for representative time periods. Fourteen measurement positions on and near the proposed site were chosen as representative of the area and its activities, including a position within the town of Arandis, and two measurement positions at identified affected dwellings remote from the site, one south of the mine near the confluence of the Swakop and Khan rivers and one to the north of the mine, 40km south of Usakos on the eastern side of the Khan River.

At all measurement positions, notes were made on the nature of the contributions to the ambient noise and identifiable noise events where applicable. Noise measurements were made of the equivalent continuous A-weighted sound pressure level, $L_{Aeq,I}$ using the 'I' (Impulse) dynamic response characteristic as recommended in SANS 10103:2004 (ref. 1), and specified in the National Noise Regulations (ref. 7). In addition, the $\mathbf{L_{90}}$ was recorded, representing the background noise.

2.3 Measurement Of Noise from Similar Operations

The approach used in this assessment was as far as possible to utilize measurements made at similar operations on the existing mine, or for operations not yet carried out on the mine, to utilize measurements from similar plant at a different location or manufacturer's data, as has had to be done for the proposed acid plant. This approach has the advantage that realistic noise values representing actual equipment maintenance condition and actual operating conditions are used in the predictions as far as possible. These measurements are tabulated in Section 3.5.

2.4. Prediction Of Noise Levels At The Proposed Site

The values measured in accordance with section 2.3. above then formed the basis of calculations to predict the noise levels at specific locations of interest outside the boundaries of the proposed mine expansion. Using the point source and attenuation-by-distance model, the following assumptions were made:

1) Acoustically hard ground conditions. This assumes that no attenuation due to absorption at the ground surface takes place. The effects of frequency-dependent atmospheric absorption were also ignored. Both assumptions represent a somewhat pessimistic evaluation of the potential noise impact.
2) Meteorological conditions. Neutral weather conditions, i.e. windless and inversionless, and standard conditions of temperature and humidity (20°C and 50%RH) were assumed, representing a neutral evaluation of the noise impact. For modeling purposes, the wind roses available for the area were used where appropriate.
3) Noise measurements were representative of normal operation. Equivalent continuous A-weighted noise levels, $L_{Aeq,I}$, measured for the operation are assumed to correctly represent the noise from that operation. Impossible-to-predict (random) single noise events louder than the continuous noise level are not taken into account, although short events which are part of the process, such as the impact noise from material transport and vehicles, for example, are fully represented in the measurements, representing a neutral to mildly optimistic evaluation of the noise impact.
4) Ambient noise levels. Measured levels were assumed typical of the environment, representing a neutral evaluation of the noise impact.

5) Screening effect of temporary stockpiles, buildings and other barriers. The effect of these temporary structures on the noise climate has been ignored, representing a pessimistic evaluation of the potential noise impact, excluding screening by the pit walls themselves,
6) Current noise control technology is assumed. No allowance is made in the noise level predictions for improvements in noise control techniques which may be incorporated into the proposed project, representing a pessimistic evaluation of the potential noise impact.
7) Worst case operational noise level assumption. The highest noise level of plant was used as the criterion value for the noise predictions at the proposed project, representing a pessimistic evaluation of the potential noise impact.
8) Worst case operational assumption. The assumption has been made that plant is located at the closest possible position it can be located to the assessment point, representing a pessimistic evaluation of the potential noise impact.

2.5. Quantifying The Noise Impact

The noise impact is quantified as the predicted increase in ambient noise level, in decibels, which can be attributed to the operation of the proposed mine expansion appropriate to the proposed operating times and days.

Three measurement positions of section 3.5 are at locations within the residential area of Arandis (position 2), or at farms remote (greater than 20km) from the mine (positions 18 and 19).

Existing noise sources include:

- Natural sounds of the bush
- Local community and domestic noise
- Transport vehicles serving the existing mine and the local community.
- Current mining and processing operations

Noise level dB(A)	Source	Subjective description
160-170	Turbo-jet engine	Unbearable
130	Pneumatic chipping and riveting (operator's position)	Unbearable
120	Large diesel power generator	Unbearable

Noise level dB(A)	Source	Subjective description
110	Circular saw Blaring radio	Very noisy
90 - 100	Vehicle on highway	Very noisy
80 - 90	Corner of a busy street Voice - shouting	Noisy
70	Voice - conversational level	Quiet
40 - 50	Average home - suburban areas	Quiet
30	Average home - rural areas Voice - soft whisper	Quiet
0	Threshold of normal hearing	Very quiet

Table 2-1: Typical noise level and human perception of common noise sources

Type of district	Equivalent continuous rating level ($L_{Req.T}$) for noise dB(A)					
	Outdoors			Indoors, with open windows		
	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)
RESIDENTIAL DISTRICTS						
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
NON RESIDENTIAL DISTRICTS						
d) Urban districts with some workshops, with business premises, and with main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Table 2-2: Acceptable rating levels for noise in districts (Ref.1)

NB: Day-time : 06:00 to 22:00, Night-time : 22:00 to 06:00

2.6. Assessing The Noise Impact

The expected response of the local community, as shown in Table 2-3 below, to the noise impact, i.e. the increase in noise level over the original ambient noise level, is primarily based on Table 5 of SANS 10103 (ref. 1), but expressed in terms of the effects of impact, on a scale of 'none' to 'very high'.

INCREASE dB	RESPONSE INTENSITY	REMARKS	NOISE IMPACT
0	None	Change not discernible to a person	None

3	None to little	Change just discernible	Very low
3 ≤ 5	Little	Change easily discernible	Low
5 ≤ 7	Little	Sporadic complaints	Moderate
7	Little	Defined by National Noise Regulations as being 'disturbing'	Moderate
7 ≤ 10	Little to medium	Sporadic complaints	High
10 ≤ 15	Medium	Change of 10dB perceived as 'twice as loud' leading to widespread complaints	Very high
15 ≤ 20	Strong	Threats of community/group action	Very high

Table 2-3: Response intensity and noise impact for various increases over the ambient noise

2.7. Response Of Communities To Blast Noise And Vibration

The characteristics of blast noise, which is transient, its manner of propagation, and the assessment of the response of a community to it, is completely different from the assessment of the mine expansion mining and equipment noise, which is either continuous or occurs for a significant proportion of the working day. In addition, there are no straightforward methods of assessment of community response to blast noise which are not based on actual blast event measurements. Currently, an International Standards Organisation committee, (see ref. 11) is considering a method of modeling the propagation of blast and other impulsive noise, but there is no reliable scientific method of predicting community response to it at present. Some good practices and mitigation methods to reduce the possible reaction to blasting are discussed in the relevant section.

3. AMBIENT NOISE MEASUREMENTS AT THE PROPOSED SITE

3.1. Introduction

Noise measurements were carried out at the proposed site to assess likely response to noise from the projected workings at the proposed mine expansion. Ambient noise measurements were made at nine locations near the property boundary, three at affected party sites, and a number within the mine to define current noise levels at the proposed ore sorter and acid plant sites.

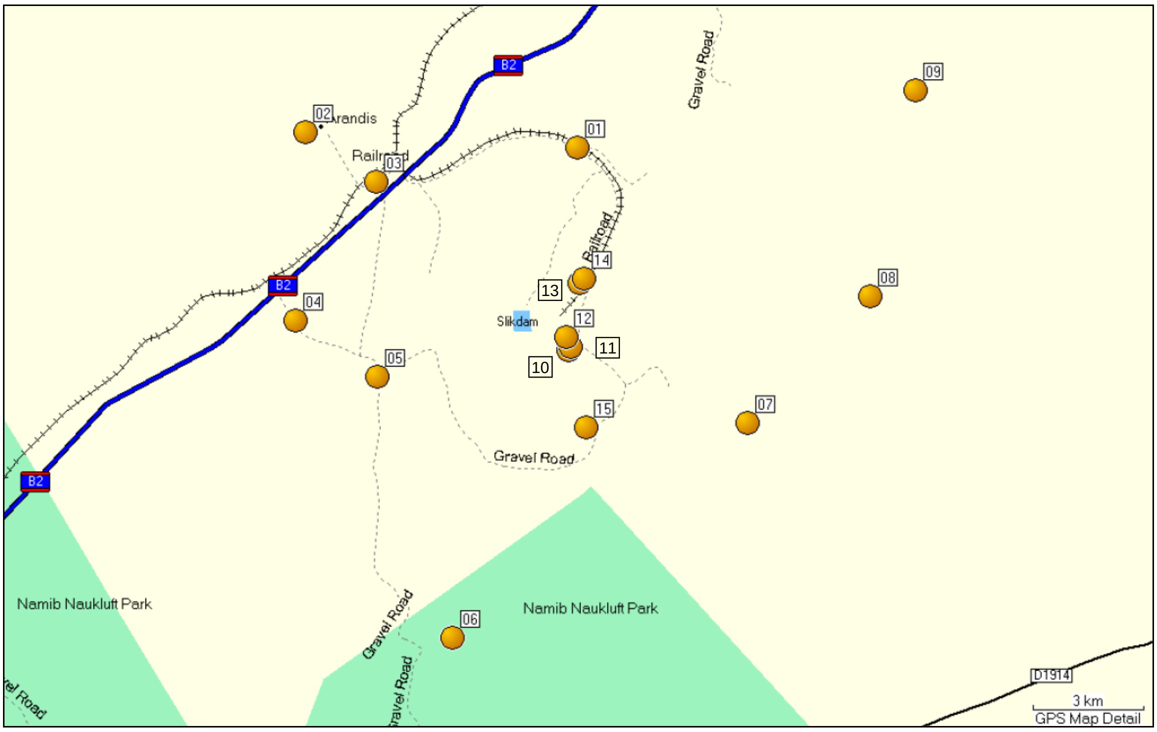

Figure 3-1 Map showing position of measuring points in the mine vicinity

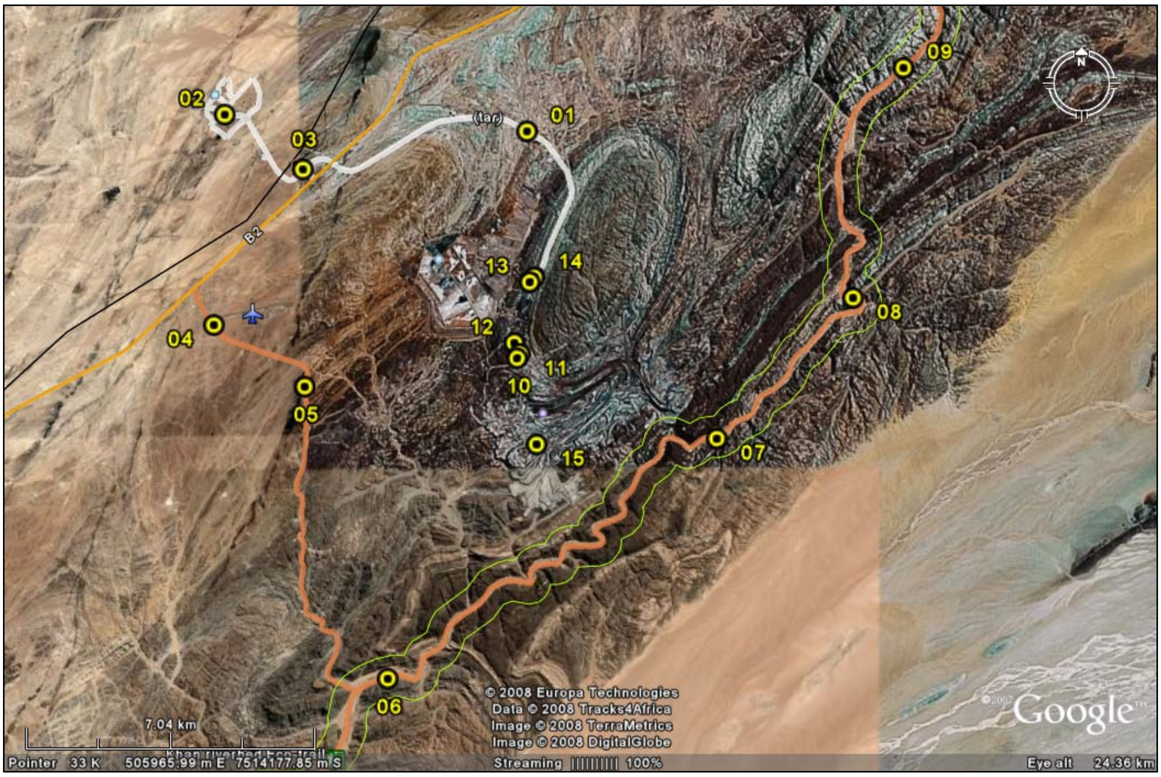

Figure 3-1 Aerial Photo showing position of measuring points in the mine vicinity

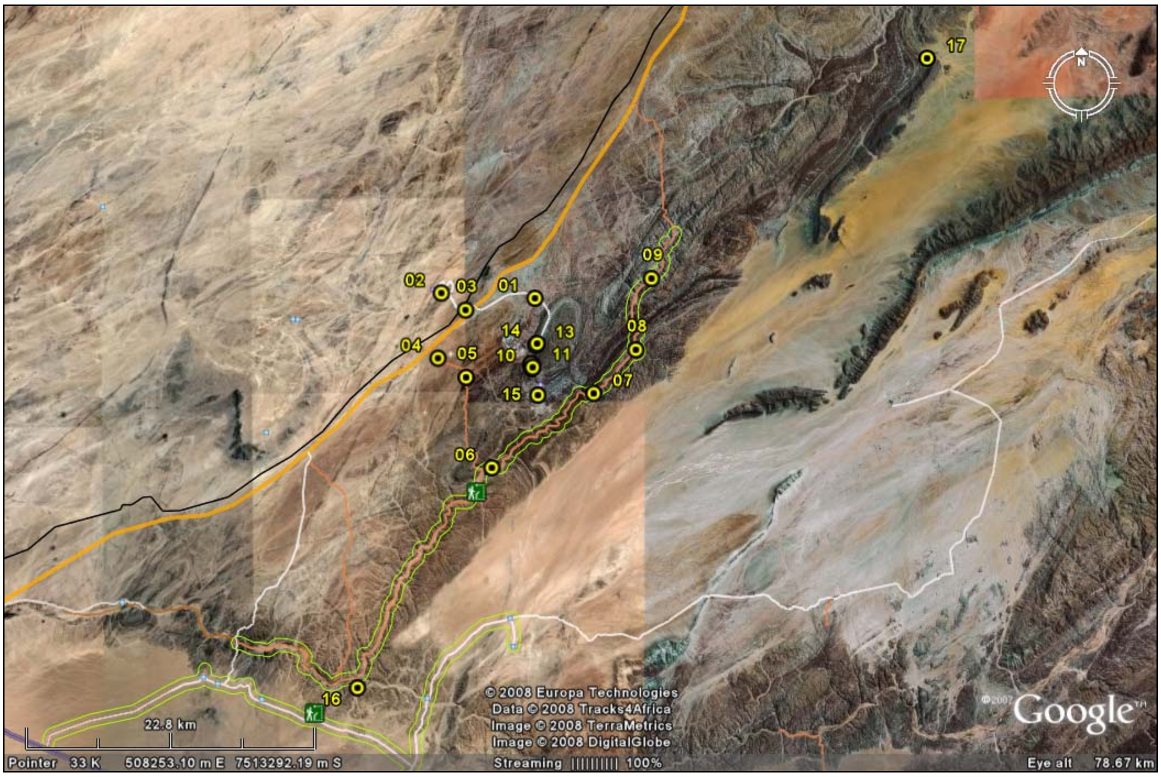

Figure 3-2 Aerial Photo showing measuring points remote from the mine

3.2. Equipment Used:

01dB Type SdB01+ Precision Integrating Sound Level Meter, serial number 10180, fitted with 01dB Microphone Type MCE210, serial number 11494, and windscreen. Field calibration using and 01dB Type CAL01 Sound Level Calibrator, serial number 990640.

3.3. Calibration Certificates:

All equipment with valid calibration certificates from the De Beer testing laboratories. The calibration certificates are available for viewing if required.

3.4. Procedures Used:

There is a recent agreement between the Namibian Government and the South African government through the South African Bureau of Standards (SABS) to assist to set up a similar Namibian organization to be concerned with the vetting of standards and the distribution of information regarding them. As there are no applicable Namibian National Noise Standards, measurements were carried out in accordance with SOUTH AFRICAN NATIONAL STANDARD - Code of practice, SANS 10103:2004, *The measurement and rating of environmental noise with respect to annoyance and to speech communication,* and as required by the regulations of the DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM. NO. R. 154. *Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989)*. Govt. Gaz. No. 13717, 10 January 1992.

3.5. Ambient Noise Measurements at the Proposed Site:

Measurements were carried out at 14 locations on and around the property as described below, including Arandis (location 2) and 2 nearby farms (locations 15 and 16). These locations were chosen for the following reasons:

1) Useful for comparison purposes after development of the site.
2) Most likely to continue to exist after developments on the site.
3) Easily identifiable and with easy access in case of need for future measurements.
4) On the roads most likely to be affected by future traffic noise changes.

Note 1: SANS 10103:2003 defines: Day-time – 06:00 to 22:00

Night-time – 22:00 to 06:00

Note 2: As the proposed mine expansion is planned to operate 24 hours, assessments have only been made for daytime and night-time periods.

Note 3: All noise levels in this report are A-weighted noise levels expressed in dB(A) re 20 microPascals, and measured according to SANS 10103:2003 (Ref. 1)

Note 4: In the Comments column of the noise tables, C - Car, Minibus or LDV, HGV – Heavy Goods Vehicle or Bus, A/c – Commercial airliner, La/c – light aircraft, c – noise level calculated from traffic count, for the measurement period (usually 10 Minutes)

Location 1

At a point 45m from the centreline of the main mine access road at the position near the only tree and isolated boulder in the area marked by a cairn as shown in the photos below. GPS coordinates: S22° 25.331′ E15° 02.723″, 636m ±5m


View towards the main mine access road **View away from mine to Arandis**

Measurement Table

Date	Time	T °C	RH %	Wind m/s mx	$L_{Aeq,I}$	L_{90}	Comments
07/11/07	11:11-11:21	31	25	<0.5	45.2	23	C=3, HGV=1
07/11/07	11:22-11:32	31	25	<0.5	43.9	23	C=3
05/12/07	10:54-11:06	20	45	<5.5	47.6	28	C=5, HGV=1
05/12/07	11:07-11:17	20	45	<3.8	45.0	29	C=9
07/12/07	16:35-16:45	25	31	<4.1	52.7	37	C=19, HGV=11
07/12/07	16:46-16:56	25	31	<4.1	46.6	32	C=9
06/12/07	18:15-18:25	20	50	<4.0	46.7	30	C=5, HGV=1
06/12/07	18:26-18:36	20	50	<4.0	49.8	30	C=1, HGV=2
06/12/07	18:37-18:47	20	50	<4.0	36.3	31	0 traffic
06/12/07	18:48-18:58	20	50	<4.0	36.3	31	0 traffic

Observations: These values are typical of a rural area with natural sounds such as bird song and wind-driven rustling of foliage, near a road which dominates the $\mathbf{L_{Aeq,I}}$ value. Note also that the $\mathbf{L_{90}}$ (the sound level exceeded for 90% of the time, and usually taken as the background noise without intruding events) is very stable at a very low 30 dB(A) during the day.

Location 2

At a point inside the Rössing foundation gardens in Arandis near the fire assembly point as shown in the photographs below. GPS coordinates: S22° 25.110′ E14° 58.421′, 587m ±7m

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
05/12/07	12:36-12:46	20	45	<1.8	55.6	43	
05/12/07	12:48-12:58	20	45	<1.8	54.1	50	
06/12/07	17:09-17:20	22	43	<1.5	50.6	44	
06/12/07	17:21-17:31	22	43	<1.5	52.0	44	
06/12/07	19:10-19:20	18	55	<1.5	54.6	48	
08/12/07	09:50-10:00	17.5	60	<1.5	52.3	43	
08/12/07	10:01-10:11	17.5	60	<1.5	49.4	40	

Observations: These values are typical of a suburban area with human activity and local traffic which dominate the $L_{Aeq,I}$ value.

Location 3

At a point behind the welcome sign to Arandis at the road intersection as shown in the photographs below. GPS coordinates: S22° 25.830′ E14° 59.538′, 604m ±5.2m

View along main access road to Arandis

View towards the mine location

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
05/12/07	11:28-11:39	20	45	<3.8	51.3	35	C=16, HGV=1
05/12/07	11:44-11:56	20	45	<3.8	48.3	34	C=5, HGV=2
05/12/07	12:10-12:20	20	45	<3.8	50.9	35	C=15, HGV=1
07/12/07	17:04-17:14	24	36	<4.6	47.8	39	C=13
07/12/07	17:15-17:25	24	36	<4.6	53.0	42	C=22, HGV=2
06/12/07	17:45-17:55	22	43	<4.5	49.5	37	C=11, HGV=1
06/12/07	17:56-18:06	22	43	<4.5	47.8	38	C=9, HGV=1
06/12/07	19:30-19:40	17	60	<3.8	49.8	37	C=9, HGV=1
06/12/07	19:41-19:51	17	60	<3.8	48.4	35	C=3, HGV=1

Note: An individual blast was measured at this position at a maximum recorded value of 87.2 dB(A)

Observations: These values are typical of a rural area with natural sounds such as bird song and wind-driven rustling of foliage, near a road which dominates the $\mathbf{L_{Aeq,I}}$ value. Note also that the $\mathbf{L_{90}}$ is very stable at approximately 35 dB(A) during the day.

Location 4

At a point on the boundary with the Arandis airport road reserve as shown in the photographs below, 15m from the centreline of the road. GPS coordinates: S22° 27.874′ E14° 58.271′, 565m ±5m

View to the remote area and Khan river **View towards main Swakopmund road**

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
08/12/07	09:20-09:30	17.5	60	<2.5	37.0	34	
08/12/07	09:31-09:41	17.5	60	<2.5	36.7	34	
07/02/08	10:49-10:59	26	62	<1.2	37.9	34	
07/02/08	11:01-11:11	26	62	<1.2	37.8	35	
05/12/07	13:40-13:50	20	44	<5.6	41.3	32	
07/12/07	15:05-15:15	25	31	<5.8	48.0	36	
07/12/07	15:16-15:26	25	31	<5.8	43.8	37	
06/12/07	15:50-16:00	22.5	43	<6.5	43.6	32	
06/12/07	16:45-16:55	22.5	43	<6.5	44.1	31	
07/12/07	17:45-17:55	25	31	<5.8	43.8	37	
06/12/07	19:58-20:08	17	60	<3.5	40.1	35	

Observations: These values are typical of a rural area with natural sounds such as bird song and wind-driven rustling of foliage. However, the main Swakpmund to Windhoek road, although remote, dominates the $\mathbf{L_{Aeq,I}}$ value and is continuously audible at the measurement point. Note also that the $\mathbf{L_{90}}$ is very stable at approximately 35 dB(A) during the day.

Location 5

At a point on the dirt road to the Khan Mine at the road edge as shown in the photographs below. GPS coordinates: S22° 28.685′ E14° 59.563″, 562m ±5.5m

View along access road to Khan mine and Khan River

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
05/12/07	13:12-13:22	20	44	<5.3	38.0	27	
05/12/07	13:23-13:34	20	44	<5.3	38.6	29	
07/12/07	15:37-15:47	25	31	<4.1	40.7	27	
07/12/07	15:49-15:59	25	31	<4.1	40.4	30	
06/12/07	16:02-16:12	22.5	43	<4.5	38.8	28	
06/12/07	16:13-16:23	22.5	43	<4.5	36.3	27	
06/12/07	16:24-16:34	22.5	43	<4.5	38.6	29	
07/12/07	18:13-18:23	21	45	<3.5	36.4	31	
07/12/07	18:24-18:34	21	45	<3.5	36.8	33	

Observations: These values are typical of a remote rural area with natural sounds which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. This value is extremely low even though noise from the plant and from the railway is sometimes audible at this position. The $\mathbf{L_{90}}$ is also very low at 30 dB(A) during the day.

Location 6

At a point in the Khan River valley close to an identifiable tree and over the rock, as shown in the photographs below. GPS coordinates: S22° 32.521′ E15° 00.742″, 314m ±5.3m

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
07/11/07	12:46-12:56	31	25	<4.0	38.8	27	
07/11/07	12:57-13:07	31	25	<4.0	40.7	28	

Observations: These values are typical of a remote rural area with natural sounds which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. The $\mathbf{L_{90}}$ is very low, below 30 dB(A) during the day.

Location 7

At a point at an island in the middle of the Khan river bed, as shown in the photographs below. GPS coordinates: S22° 29.367′ E15° 05.422′, 381m ±6.3m


Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
07/11/07	13:30-13:40	31	25	<3.2	40.2	27	
07/11/07	13:41-13:51	31	25	<4.0	44.9	29	

Observations: These values are typical of a remote rural area with natural sounds, particularly birdsong and wind noise which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. The $\mathbf{L_{90}}$ is very low, below 30 dB(A) during the day.

Location 8

At a point by an identifiable rock in the Khan river bed, as shown in the photographs below. GPS coordinates: S22° 27.517′ E15° 07.358′, 417m ±5.1m

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
07/11/07	14:06-14:16	31	25	<4.5	42.1	22	
07/11/07	14:17-14:27	31	25	<4.5	39.5	27	

Observations: Observations: These values are typical of a remote rural area with natural sounds, particularly birdsong and wind noise which dominate the **$L_{Aeq,I}$** value during the day. The **L_{90}** is very low, below 30 dB(A) during the day.

Location 9

At a point by an identifiable tree in the Khan river bed, as shown in the photographs below. GPS coordinates: S22° 24.495′ E15° 08.074′, 454m ±5.5m

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
07/11/07	15:00-15:10	31	25	<4.5	44.8	34	

Observations: These values are typical of a remote rural area with natural sounds, particularly birdsong and wind noise which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. The $\mathbf{L_{90}}$ is low, at 34 dB(A) during the day.

Location 10

Ore sorter plant proposed location at the primary reclaim area at a point at the edge of the dirt road as shown in the photographs below. GPS coordinates: S22° 28.311′ E15° 02.582′, 568m ±5m

View towards primary reclaim site **View towards main plant**

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
08/11/07	10:23-10:33	31	25	<2.5	57.2	52	
09/11/07	11:20-11:30	28	30	<2.5	61.3	57	
09/11/07	11:34-11:44	28	30	<2.5	60.3	58	
08/11/07	13:40-13:50	31	25	<5	55.8	52	

Observations: These values are typical of an industrial area with continuous process plant noise from the primary reclaim area dominates the $\mathbf{L_{Aeq,I}}$ value. The $\mathbf{L_{90}}$ is variable between 52 and 58 dB(A).

Location 11

Ore sorter plant proposed location at the reclaim area end of the conveyor 20m from it at the pipeline as shown in the photographs below. GPS coordinates: S22° 28.255′ E15° 02.622′, 560m ±5m

View towards proposed ore sorter site

View towards primary reclain area

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
08/11/07	10:38-10:48	31	25	<2.5	60.9	59	
09/11/07	11:03-11:13	28	30	<2.5	62.5	61	HGV=1
09/11/07	11:48-11:53	28	30	<2.5	62.5	61	
08/11/07	13:25-13:35	31	25	<5	59.4	58	

Observations: These values are typical of an industrial area with continuous process plant noise from the primary reclaim area dominates the $\mathbf{L_{Aeq,I}}$ value. The $\mathbf{L_{90}}$ is very repeatable at about 60 dB(A).

Location 12

Ore sorter plant proposed location at the plant end of the conveyor 20m from it at the end of the pipeline as shown in the photographs below. GPS coordinates: S22° 28.111′ E15° 02.544′, 568m ±5.5m

View towards proposed ore sorter site

View towards compressor house

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
08/11/07	13:10-13:20	31	25	<5	65.4	63	Compressor house dominates

Observations: These values are typical of an industrial area with continuous process plant. The noise from the compressor house dominates the $\mathbf{L_{Aeq,I}}$ value at this point, the noise from the conveyor being of secondary importance. The $\mathbf{L_{90}}$ is very repeatable at 63 dB(A).

Location 13

Acid plant proposed location at the pipeline valve chest as shown in the photographs below. GPS coordinates: S22° 27.311′ E15° 02.762′, 598m ±5.3m

View towards office area/main entrance left

View of pipeline, proposed site to

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
09/11/07	12:50-13:00	30	24	<4.0	50.5	47	
09/11/07	13:02-13:12	30	24	<3.8	51.5	46	
09/11/07	13:42-13:52	30	24	<3.8	49.9	44	

Observations: These values are typical of an industrial area with continuous process plant noise at remote locations dominating the $\mathbf{L_{Aeq,I}}$ value. The $\mathbf{L_{90}}$ is very repeatable around 46 dB(A).

Location 14

Acid plant proposed location near the vehicle compound as shown in the photographs below. GPS coordinates: S22° 27.250′ E15° 02.825′, 597m ±5m

View to office area/main entrance **View to acid plant site in mid-distance**

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
09/11/07	13:16-13:26	30	24	<3.8	50.9	44	
09/11/07	13:27-13:37	30	24	<3.8	51.1	45	

Observations: These values are typical of an industrial area with remote continuous process plant noise dominating the $\mathbf{L_{Aeq,I}}$ value. The $\mathbf{L_{90}}$ is very repeatable at about 45 dB(A).

Location 15

At the pit rim at the viewpoint as shown in the photographs below. GPS coordinates: S22° 29.442′ E15° 02.860 ′, 548m ±5.6m

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
Thur 31/01/08	12:20-12:31	26	28	<2.0	57.1	53	

Location 16

At the entrance gate of the plot near the confluence of the Swakop and Khan rivers as shown in the photographs below. GPS coordinates: S22° 41.860′ E14° 54.553′, 203m ±7m

View away from plot entrance **View towards dwelling in middle distance**

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
07/12/07	08:56-09:12	23	29	<1.6	42.0	31	
07/12/07	09:13-09:36	23	29	<1.6	43.0	29	
07/12/07	09:37-09:47	23	29	<1.5	41.4	33	
07/12/07	09:48-10:13	23	29	<1.5	41.7	31	

Observations: These values are typical of a remote rural area with natural sounds, particularly birdsong and wind noise in foliage which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. The $\mathbf{L_{90}}$ is very low at 30 dB(A) during the day.

Location 17

On the stoop of the farm Wolfskoppe as shown in the photographs below. GPS coordinates: S22° 15.117′ E15° 20.732 ′, 818m ±7m

View from stoop

Measurement Table

Date	Time	T °C	RH %	Wind m/s	$L_{Aeq,I}$	L_{90}	Comments
Sat02/02/08	12:15-12:42	36	15	<5.0	42.0	33	
Sat02/02/08	12:43-12:58	36	15	<5.0	46.1	34	
Sat02/02/08	13:00 -13:10	36	15	<5.0	39.5	30	
Sat02/02/08	13:13 -13:23	36	15	<5.0	38.1	28	
Sat02/02/08	13:25 -13:35	36	15	<5.0	40.2	27	

Observations: These values are typical of a remote rural area with natural sounds, particularly birdsong and wind noise in foliage which dominate the $\mathbf{L_{Aeq,I}}$ value during the day. The $\mathbf{L_{90}}$ is very low at 30 dB(A) during the day.

3.6. Measurements at a Mine Using Similar Procedures & Equipment

Measurements were made of operations at the mine using similar equipment to that proposed for the SK4 site. The three main operations measured were the drilling of blast holes, the loading of haul trucks, and the pilot ore sorter plant to quantify their noise output.

3.6.1. Ore Sorter Pilot Plant

Position 1

At a point 20m from the plant structure as shown in the photographs below. GPS coordinates: GPS coordinates: S22° 28.014′ E15° 02.403′, 568m ±5m

Position 2

At a point 20m from the plant structure as shown in the photographs below. GPS coordinates: GPS coordinates: S22° 27.995′ E15° 02.403′, 560m ±4.7m

Position 3

At a point 20m from the plant structure as shown in the photograph below. GPS coordinates: GPS coordinates: S22° 27.991′ E15° 02.423′, 558m ±4.7m

Measurement Table

Octave band measurements were carried out on Thursday 6 December 2007 giving the following worst case values from 4 sets of results, all measured at 20m from the structural frame of the sorter and normalized to the standard distance of 30m. All values are in dB re 20 microPascals.

Freq (Hz.)	Posn 1	Posn 2	Posn 3
31.5	72.8	73.1	76.3
63	81.8	81.9	75.9
125	74.1	73.2	75.2
250	70.4	71.1	71.2
500	69.6	71.2	73.3
1k	67.8	70.3	76.8
2k	67.8	72.2	77.2
4k	64.4	69.8	78.2
8k	68.2	65.0	72.5
dB(A)	77.5	85.0	84.0

3.6.2. The Drilling Operations:

Measurements were made at a distance of 30m from the assumed acoustic center of drilling rigs, over a full drilling cycle. Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max. The following relevant measurements were recorded.

Primary Drilling Rigs

Basil Read Drilling Rigs

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
Primary	69.2	75.2	79.3	79.2	75.7	77.5	73.5	66.4	60.5	81.1
Basil Read	69.7	82.5	85.1	77.8	70.7	71.9	74.9	67.7	66.6	81.2

For calculation and prediction purposes the maximum measurement cycle value of 81.2 dB(A) at 30m for a single rig has therefore been used.

3.6.3. The Loading operation:

Measurements were made at a distance of 30m from the assumed acoustic center of the operation, over a number of full loading cycles. Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max.

General View of the Loading Operation in the Open Pit

The following relevant measurements were recorded.

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
	81.8	88.4	88.9	88.5	78.4	77.1	76.0	69.1	63.8	85.2

For calculation and prediction purposes the maximum measurement cycle value of 85.2 dB(A) at 30m has therefore been used.

3.6.4 Offloading Operation

Measurements were made at a distance of 45m from the assumed acoustic center of the operation, over a number of full loading cycles. The values in the following table are normalized to a distance of 30m. Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max.

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
Tipping	80.0	92.0	92.5	85.7	88.9	90.3	81.4	75.9	63.7	83.4
Rear	80.4	81.4	79.7	76.4	72.3	67.9	64.9	59.9	55.6	76.3

For calculation and prediction purposes the maximum measurement cycle value of 83.4 dB(A) at 30m has therefore been used.

3.6.5. The Acid Plant:

<u>Acid Plant similar to the Proposed Plant</u>

These sound pressure level values are obtained from the acid plant manufacturer's proposal and used only for the preliminary prediction modeling. They are normalized to a measurement distance of 30m.

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
	75.0	75.0	75.0	75.0	79.0	79.0	73.5	67.5	61.5	82.0

3.6.6. The Crusher Plant

All measurements were made at 30m from the nominal boundary of the plant. Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max.


Position 1

Position 2

Position 3

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
Posn 1	80.1	79.5	76.7	72.0	75.4	75.4	74.4	67.3	60.0	79.9
Posn 2	83.6	82.6	80.8	74.8	78.5	79.2	72.9	67.1	59.8	82.5
Posn 3	81.2	79.5	80.5	79.0	79.3	77.6	74.8	67.5	60.4	82.0

3.6.7. Compressor House and Coolers

The original noisy plant has been replaced by quieter new compressors. The primary noise source is now the bank of coolers visible to the left of the compressor house.

Compressor House and Cooler Bank

All measurements were made at 30m from the nominal boundary of the plant.

Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max.

Freq (Hz.)	31.5	63	125	250	500	1k	2k	4k	8k	dB(A)
SPL	75.9	77.5	75.1	74.7	71.7	64.7	60.9	54.2	49.5	72.2

3.6.8 The Rodmill


View of the Rodmills, two to the left and two to the right of the centreline

All measurements were made at 30m from the nominal centreline of the plant. All four mills were operating during the measurements. Temperature 31.0°C, Humidity 40%, Wind speed 2.0 m/s max.

Freq (Hz.)	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dB(A)**
SPL	86.8	86.5	86.5	83.7	85.5	84.2	81.1	76.2	67.0	88.5

4. NOISE MODELING

4.1 Noise Modeling Methodology

The noise levels within and around the Rössing mining site were estimated with the use of the internationally accepted prediction software package MITHRA. MITHRA was developed by the CSTB (Centre for the Science and Technology of Buildings), and has been fully functional as a software program since 1987, utilised in many countries in the European Union (EU) and the USA for the modeling of environmental noise and noise planning.

The model can take into account several parameters as input, including:

- Site three-dimensional topography and ground types.
- Existing and future building layout and noise barriers.
- Meteorological effects.
- The introduction of road, rail, as well as industrial area and point noise sources.
- The incorporation of noise measurements to assist in the determination of noise emissions from existing noise sources.

- Noise prediction analysis utilising source sound power spectra in octave bands, as recommended by the model or taken from actual measurements.
- Providing an integrated environment for noise predictions under different scenarios of operation.

For the noise propagation in the Rössing mine area, the daytime and night-time wind direction frequencies were taken into consideration. The noise propagation calculations in the model were performed in accordance with ISO 9613 "Acoustics - Attenuation of Sound Propagation Outdoors". The main assumptions adopted in the noise modeling were:

- Daytime temperature and humidity 30°C and 25% respectively.
- Night-time temperature and humidity 15°C and 60% respectively.
- The ground was considered to be reflective.

Several scenarios were considered for daytime and night-time conditions, in order to cover the current operations, the proposed expansion and the cumulative total. The current and proposed phase-1 expansion layout for the mining, ore loading and offloading, stockpiling, waste dumps and processing infrastructure were set up in the model at the appropriate locations, as can be seen in the following figure. The model was run initially with only the existing sources for the generation of the present situation. The second model run covered only the additional sources due to the proposed phase-1 expansion, and the third all the sources together, in order to produce the cumulative total.

The main noise sources of the existing operations are:

- The mining activities at the existing pit.
- The ore hauling trucks to the primary crusher.
- The offloading of the trucks at the primary crusher.
- The primary crusher.
- The hauling trucks to the waste rock dump.
- The dumping of waste rock from the mining operations.
- The conveyor belts from the primary crusher to the rod mills.

- The pilot ore sorting plant.
- The fine crushing plant.
- The rod mills.

The main additional noise sources of the proposed phase-1 expansion entail:

- The mining activities at the SK4 location.
- The ore hauling trucks to the primary crusher.
- The offloading of the trucks at the primary crusher.
- The hauling trucks to the waste rock dump.
- The dumping of waste rock from the mining operations.
- The ore sorting plant.
- The loading of trucks with waste from the sorting plant.
- The hauling trucks to the sorter waste dump.
- The offloading operations at the sorter waste dump.
- The acid plant.

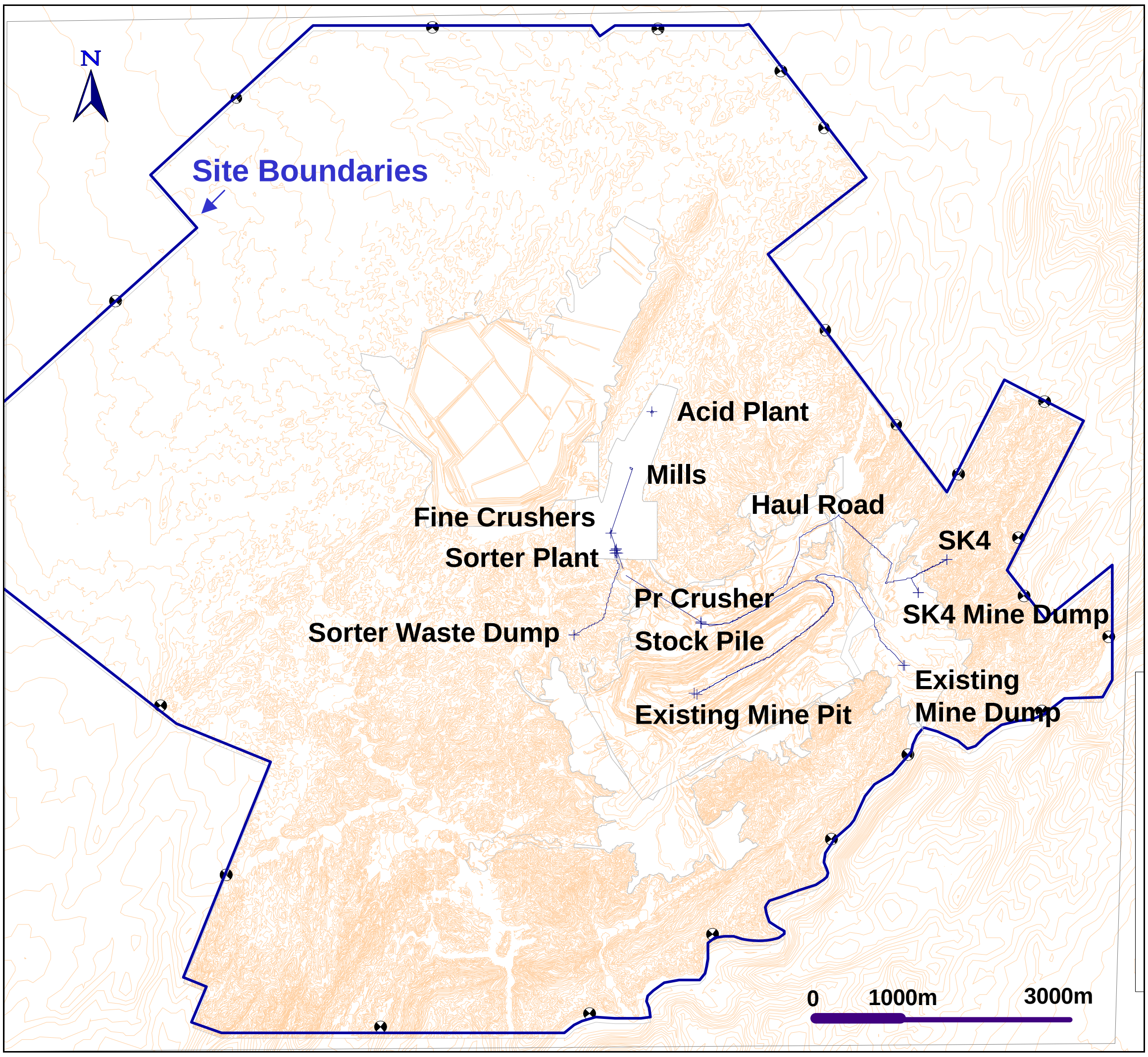

Figure 4-1: Rössing Mine Existing and Phase-1 Expansion Main Noise Sources

Most of the source noise emissions were determined via measurements at the existing equipment currently used at the site. The acid plant emissions were obtained from the manufacturer and the acid plant stack noise emissions from the DDA-JHC emissions database for metal stacks. Details of the noise measurements can be seen in Section 3. It should be noted that noise measurements will be taken at a similar acid plant in South Africa, in order to confirm the values utilised in this study.

For the estimation of the current number of ore and waste dumping trucks, the following quantities were used:

- Weight of empty truck: 138 t.

- Full weight of truck: 324 t.
- Waste from mine: 58,618 t/d.
- Ore: 27,392 t/d.

The resulting number of trucks for the current operations scenario were:

- Ore: 147 trucks/d.
- Waste from mine: 315 trucks/d.

For the estimation of the number of ore and waste dumping trucks of the phase-1 expansion, the following quantities were used:

- Weight of empty truck: 138 t.
- Full weight of truck: 324 t.
- Waste from ore sorter plant: 10,080 t/d.
- Waste from mine: 18,000 t/d.
- Ore: 5,000 t/d.

The resulting number of trucks were:

- Ore: 27 trucks/d.
- Waste from mine: 97 trucks/d.
- Waste from ore sorter plant: 54 trucks/d.

The mining operations were assumed to take place 24 hours a day, seven days a week. The acid plant stack was assumed to be 50m high.

Table 4.1 below shows the noise power levels of all the major noise sources for the existing Rössing mine operations utilised in the noise modeling.

Description	**Source ID**	**Sound Power**	**Unit**	**Daytime Operation**	**Night-time Operation**	**Coordinates**		
				(min)	**(min)**	**(X)**	**(Y)**	**(Z)**
Drilling at existing pit	R0s_MP_drl_01	107.5	dBA	960	480	5456.4	-53701.7	260.1
Loading at existing pit	R0s_MP_ld_01	107.8	dBA	960	480	5429.5	-53686.1	258.6
Bulldozer at existing	R0s_MPw_b_01	116	dBA	960	480	7922.0	-53356.0	512.1

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		
				(min)	(min)	(X)	(Y)	(Z)
mining waste dump								
Offloading at existing mining waste dump	R0s_MPw_fld_01	116	dBA	960	480	7905.1	-53358.6	510.7
Primary crusher	R0s_PrCr_01	98.1	dBA	960	480	5513.6	-52848.7	537.6
Offloading at primary crusher	R0s_PrCr_fld_01	116	dBA	960	480	5513.9	-52850.2	538.1
Pilot sorter	R0s_Sort_02a	106.9	dBA	960	480	4434.7	-51786.4	569.4
Haul trucks to primary crusher	R0os_haul_pit01	117.6	dBA/m	960	480	N/a	N/a	Var.
Haul trucks to existing mine waste dump	R0os_haul_pit02	124	dBA/m	960	480	N/a	N/a	Var.
Conveyor belt from primary crusher to sorter	R0s_cvb_01	112	dBA/m	960	480	N/a	N/a	Var.
Conveyor belt from sorter to rod mills	R0s_cvb_02	112.8	dBA/m	960	480	N/a	N/a	Var.
Fine crusher plant	R0s_Crush_a_01	105.5	dBA/m^2	960	480	N/a	N/a	Var.
Rod mills	R0s_RMilll_a_01	90.1	dBA/m^2	960	480	N/a	N/a	Var.

Table 4-1: Rössing Mine Existing Operations Sound Power Emission Levels

Table 4.2 shows the noise power levels of all the major noise sources for the proposed Rössing mine extension utilised in the noise modeling.

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		
				(min)	(min)	(X)	(Y)	(Z)
Acid plant stack exit	Ros_Acid_Pch_01	111.0	dBA	960	480	4930.51	-50337.3	633.9
Offloading at primary crusher	Ros_PrCr_fld_01	116.0	dBA	960	480	5514.49	-52850	538.1
Drilling at SK4	Ros_SK4_drl_01	107.5	dBA	960	480	8430.84	-52103.8	540.0
Loading at SK4	Ros_SK4_ld_01	107.8	dBA	960	480	8428.85	-52105.5	539.0
Bulldozer at mining waste dump	Ros_SK4w_b_01	116.0	dBA	960	480	8093.92	-52501.3	518.0
Offloading at mining waste dump	Ros_SK4w_fld_01	116.0	dBA	960	480	8093.93	-52494.1	517.4
Sorter 1a	Ros_Sort_01a	106.9	dBA	960	480	4500.27	-52026.2	565.5
Sorter 1b	Ros_Sort_01b	106.9	dBA	960	480	4505.01	-52024.4	565.4
Sorter 1c	Ros_Sort_01c	106.9	dBA	960	480	4509.44	-52022.1	565.3
Sorter 1d	Ros_Sort_01d	106.9	dBA	960	480	4514.5	-52020.6	565.2
Sorter 2a	Ros_Sort_02a	106.9	dBA	960	480	4486.58	-51986.8	566.2
Sorter 2b	Ros_Sort_02b	106.9	dBA	960	480	4491.64	-51985	566.1
Sorter 2c	Ros_Sort_02c	106.9	dBA	960	480	4496.7	-51982.9	566.0
Sorter 2d	Ros_Sort_02d	106.9	dBA	960	480	4502.39	-51981.2	566.0

Description	Source ID	Sound Power	Unit	Daytime Operation	Night-time Operation	Coordinates		
				(min)	(min)	(X)	(Y)	(Z)
Loading waste at sorter pile	Ros_Sortp_ld_01	107.8	dBA	960	480	4481.65	-52028.4	561.8
Bulldozer at sorter waste dump	Ros_swb_01	116.0	dBA	960	480	3994.46	-53004.5	534.3
Offloading at sorter waste dump	Ros_swol_01	116.0	dBA	960	480	3996.98	-52996.5	534.9
Haul trucks to primary crusher	Ros_hSK4_Ln01	73.0	dBA/m	960	480	N/a	N/a	Var.
Haul trucks to mine waste dump	Ros_hSK4w_Ln01	79.0	dBA/m	960	480	N/a	N/a	Var.
Haul trucks to sorter waste dump	Ros_hsw_01	77.8	dBA/m	960	480	N/a	N/a	Var.
Acid plant (walls)	Ros_Acida_Pl_01	101.9	dBA/m^2	960	480	N/a	N/a	Var.
Acid plant (stack walls)	Ros_Acid_Pch_02	83.6	dBA/m^2	960	480	N/a	N/a	Var.
Rod mills	Ros_RMilll_a_01	71.0	dBA/m^2	960	480	N/a	N/a	Var.
Crusher plant	Ros_Crush_a_01	86.5	dBA/m^2	960	480	N/a	N/a	Var.

Table 4-2: Rössing Mine Expansion Equipment Sound Power Emission Levels.

4.2 Noise Modeling Results

Figure 4-2 and Figure 4-3 below show the noise contours around the Rössing mining operations due to the proposed expansion. It should be noted that the levels represent the noise contribution of the proposed expansion without the implementation of any mitigation measures. The noise of all of the proposed expansion noise sources was taken into consideration.

The 45 dBA (daytime) and 35 dBA (night-time) recommendations which have been used here were taken from the relevant South African National Standards for noise in rural areas. These are comparable with other international practices. It can be seen that for the daytime conditions the 45 dBA contour falls well within the Rössing mine site boundaries and does not extend beyond a 2km radius from the various sources. Similarly, the night-time noise contribution of 35 dBA does not extend beyond the mine's boundaries and extends a maximum of 3km around the various sources.

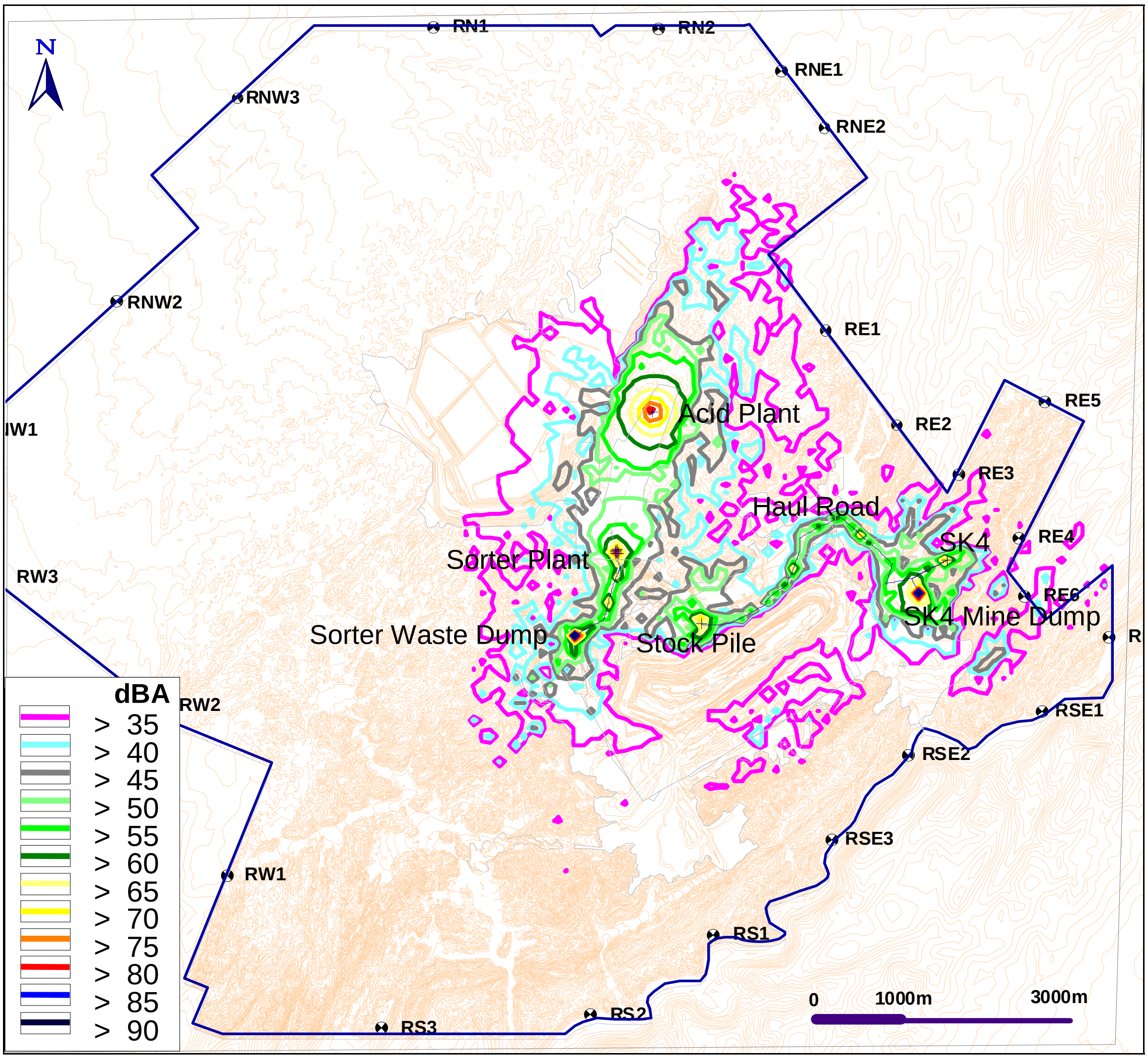

Figure 4-2: Daytime Noise Contribution due to Mine Expansion

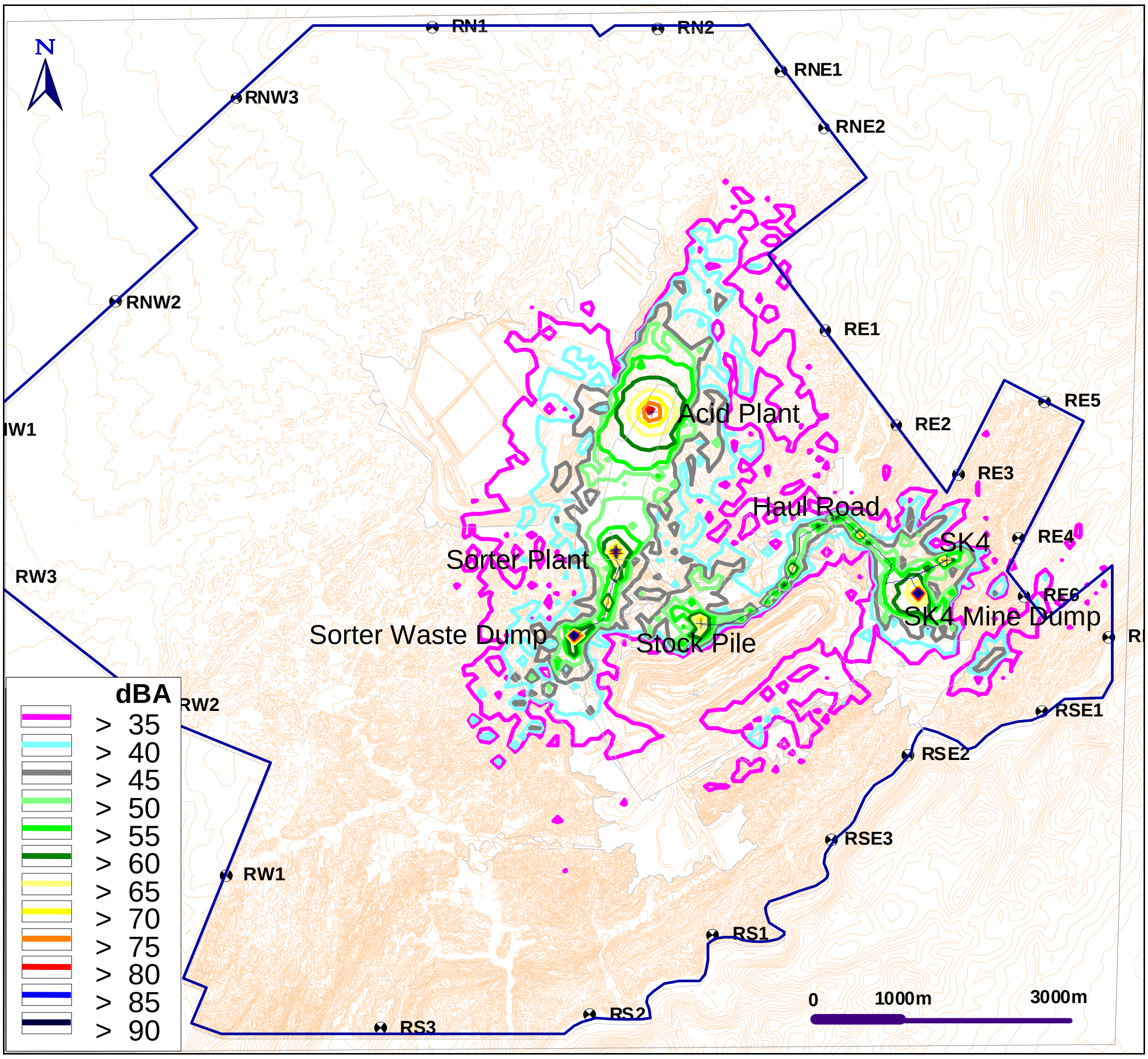

Figure 4-3: Night-time Noise Contribution due to Mine Expansion

Taking into consideration the existing noise sources due to the current mine operations in addition to the proposed expansion, the cumulative total scenario was generated. In this scenario the cumulative noise levels were estimated for the areas within and around the site, with the assumption that both existing and expansion operations were taking place simultaneously (see Figure 4-4 and 4-5).

As a worst-case scenario, the existing mine waste dump was assumed to be situated close to the south-eastern boundary. It can be seen that the noise contours of 45 dBA and 35 dBA are within the site's boundaries for both daytime and night-time respectively, with the only exception being a small area outside the south-eastern boundary.

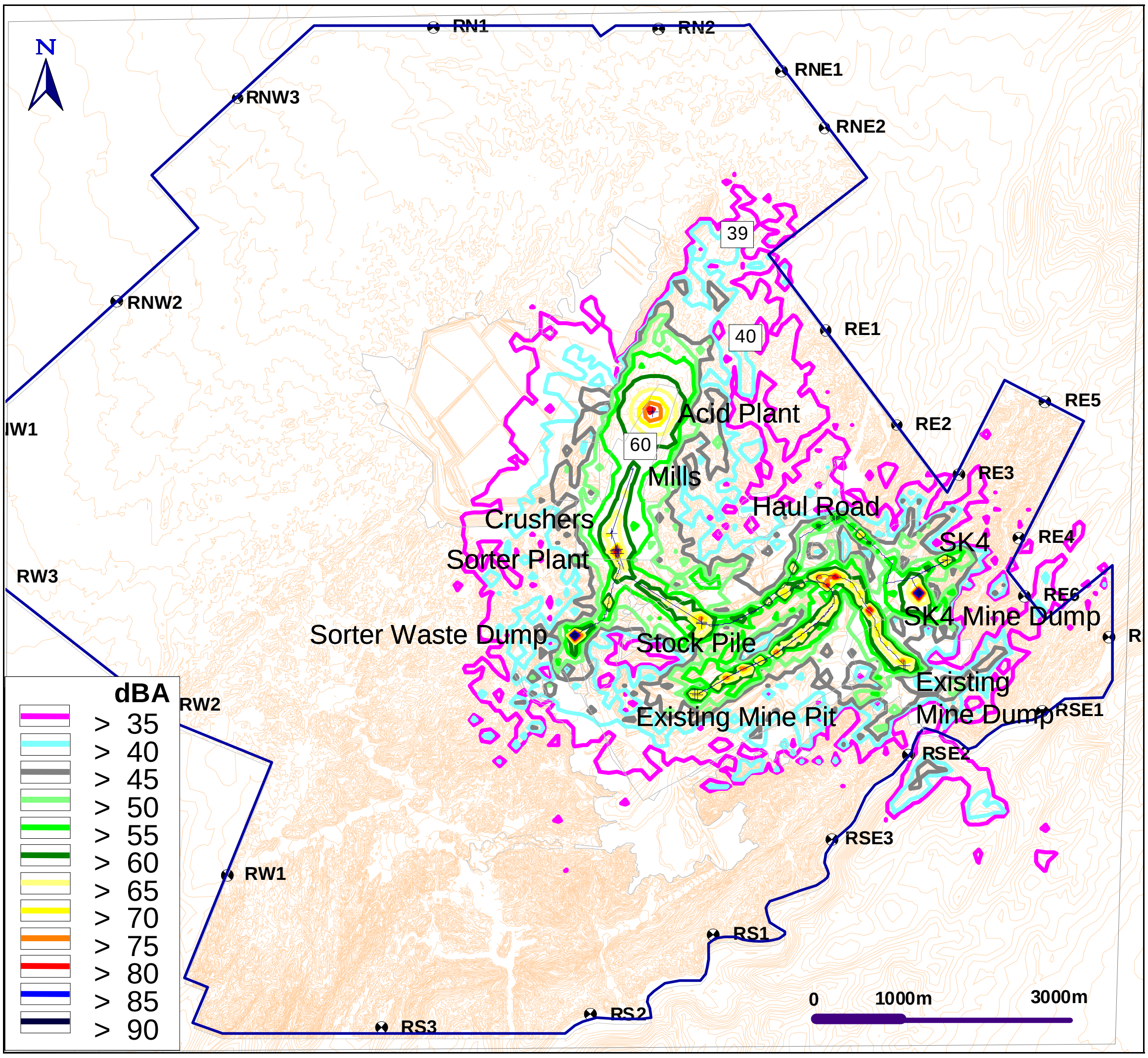

Figure 4-4: Day-time Cumulative Total due to Existing and Expansion Operations

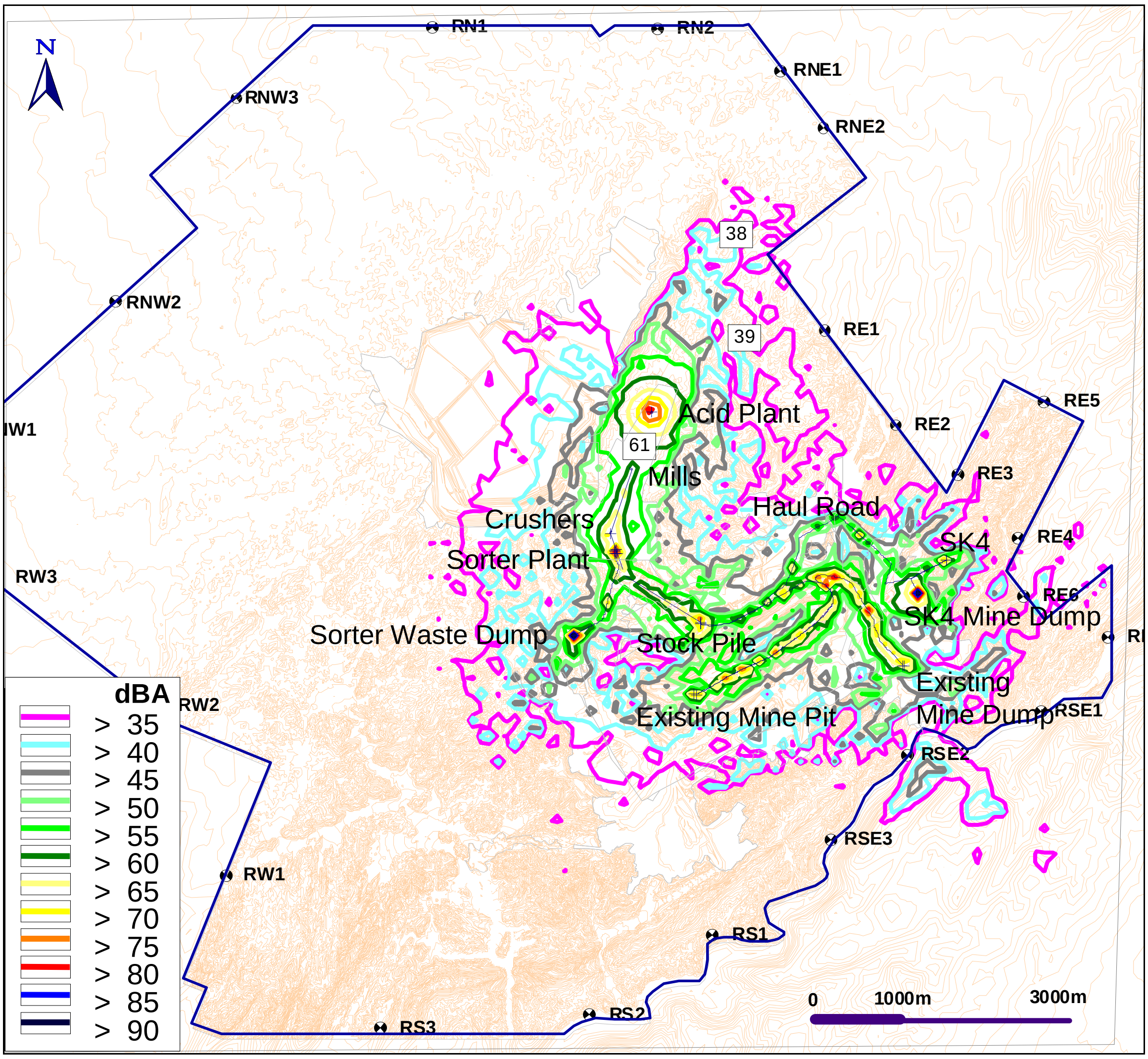

Figure 4-5: Night-time Cumulative Total due to Existing and Expansion Operations

In order to assess the cumulative noise impact of the various sources' contribution to the rural daytime and night-time noise level guidelines of 45 dBA and 35 dBA respectively, the following Figures 4-6 and 4-7 were generated. These show the resulting cumulative total noise level due to the current and proposed extension operations above the 45 dBA and 35 dBA guidelines for the daytime and night-time conditions respectively.

It can be seen that under daytime conditions, the noise contour that represents the 1 dBA noise level increase above the 45 dBA guideline is well contained within the mine's boundaries, apart from a small area adjacent to the south-eastern boundary (see Figure 4-6).

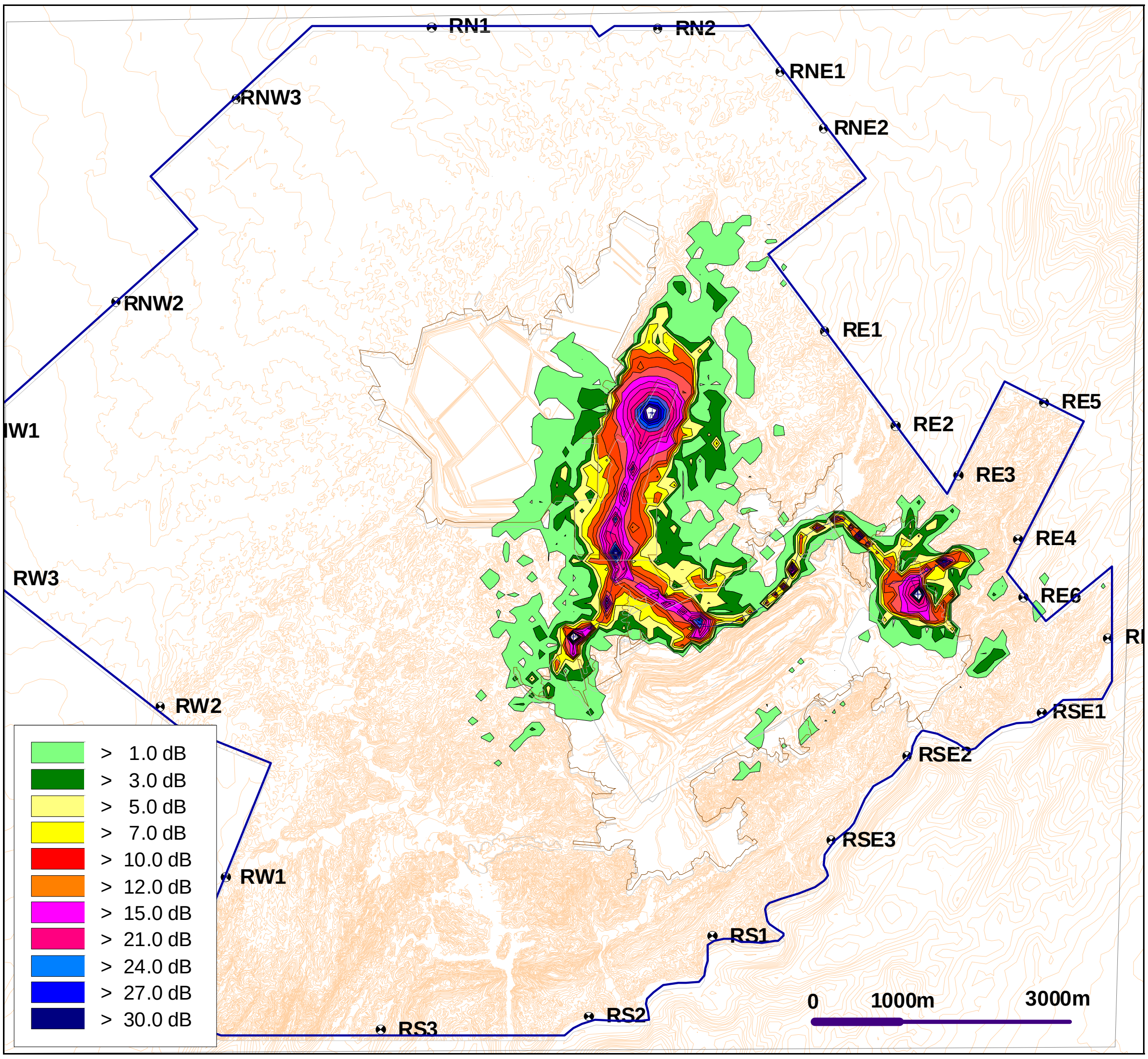

Figure 4-6: Daytime Noise Level Increase Above the 45 dBA Guideline

For night-time conditions, the 1 dBA increase above the 35 dBA contour falls well within the northern and western boundaries and extends beyond the eastern boundary by approximately 1 km. At a certain location along the south-eastern boundary, the increase of the noise level above the 35 dBA guideline is expected to be more than 12dBA (see Figure 4-5). It should be noted, however, that as soon as the deposition of the existing mining waste moves to another dumping location further away from the site's boundaries, this impact area outside the south-eastern boundary will be eliminated.

From the same Figure 4-7 it can be seen that the 3 dBA increase contour, that represents "very low" noise impact, falls primarily within the site's boundaries, except along the south- eastern boundary.

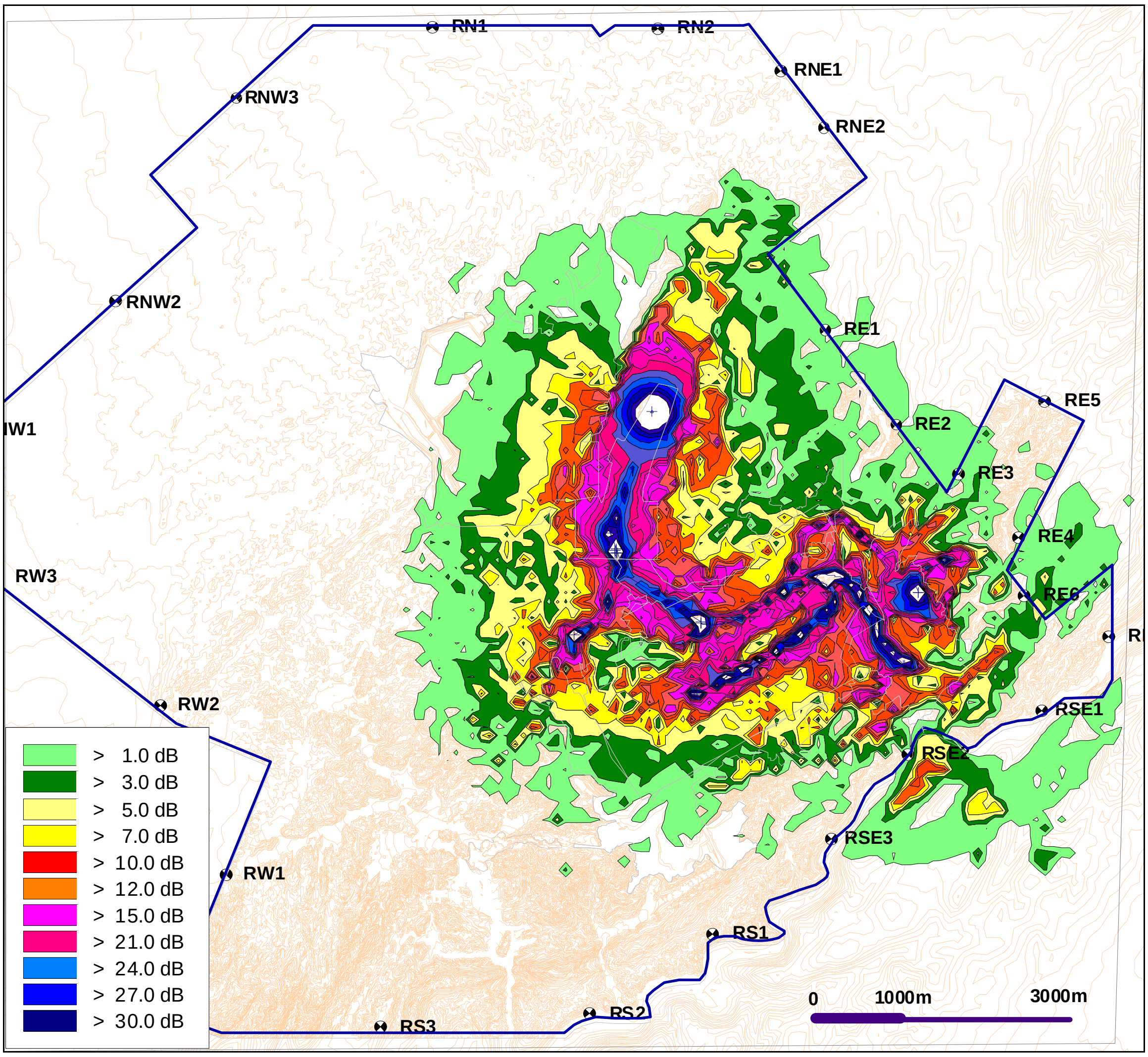

Figure 4-7: Night-time Noise Level Increase Above the 35 dBA Guideline

The noise levels at several discrete receptors along the Rössing mine boundaries were also estimated. The location of these receptors can be seen in the Figure 4-8 below. The noise level contribution of the phase-1 expansion noise sources, as well as the cumulative total that includes the existing operations, can be seen in Table 4-3 below. A noise level contribution of below 25 dBA can be considered negligible since firstly, the existing noise level there would be higher than 30 dBA, even during the night, and secondly, the guidelines for daytime and night-time conditions are 45 dBA and 35 dBA respectively. It can be seen that at none of the boundary receptors, the noise level exceeded the above-mentioned guidelines. It should be noted, however, that based on the results depicted in Figure 4-7, there will be exceedance of the 35 dBA night-time guideline by more than 12 dBA, approximately 300m outside the south-eastern boundary of the site.

The variations of the estimated daytime and night-time levels are attributed to the different wind conditions prevailing during day and night-time. The boundary with the highest noise levels at the discrete receptors was the eastern one, however, only exceeding the guidelines for night-time. This is at the access road to the mine from the Khan River valley where the noise sources and receiver positions are at a high level and, until the SK4 pit goes below the current ground surface, noisy activities will have direct line of sight to these areas.

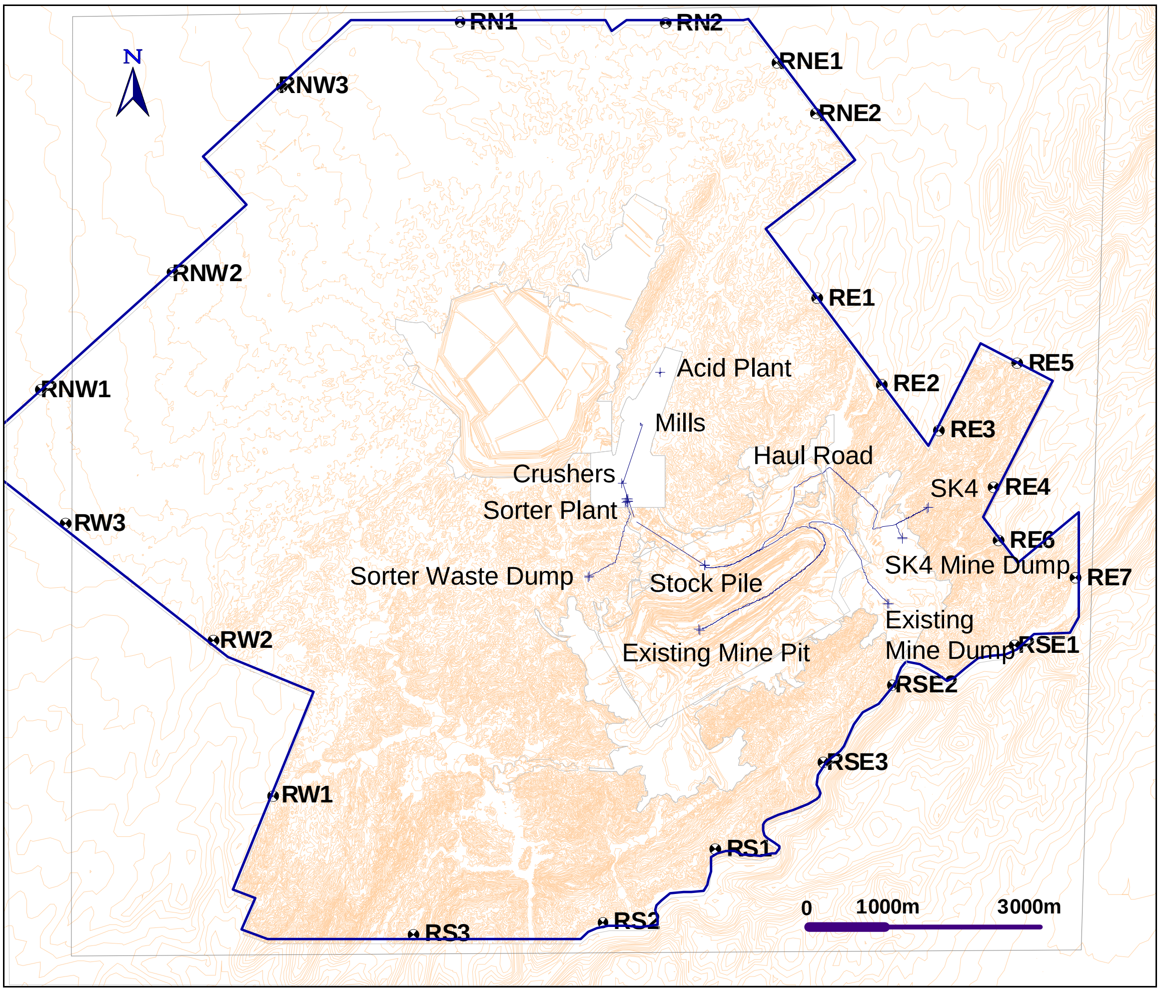

Figure 4-8: Discrete Receptor Locations Along the Rössing Mine Site Boundaries

Recept. ID	Location	Daytime Expansion Contribution[1] (dBA)	Night-time Expansion Contribution (dBA)	Daytime Cumulative Total[2] (dBA)	Night-time Cumulative Total (dBA)
RE1	East boundary	32.2	31.3	32.9	32.0
RE2	East boundary	28.4	27.7	30.4	29.5
RE3	East boundary	34.6	33.4	35.5	34.4
RE4	East boundary	31.9	31.0	32.8	31.8
RE5	East boundary	28.9	27.8	30.2	29.1
RE6	East boundary	27.6	27.1	29.3	28.6
RE7	East boundary	19.0	18.5	21.6	21.0
RN1	North boundary	15.8	15.3	16.6	16.0
RN2	North boundary	19.0	17.9	19.8	18.7
RNE1	North-east boundary	21.3	20.2	22.4	21.3
RNE2	North-east boundary	27.2	26.0	27.6	26.5
RNW1	North-west boundary	0.0	0.0	0.0	0.0
RNW2	North-west boundary	14.3	14.9	15.1	15.7
RNW3	North-west boundary	16.3	16.6	16.8	17.0
RS1	South boundary	4.9	5.4	10.1	10.8
RS2	South boundary	7.5	8.6	11.0	12.1
RS3	South boundary	16.5	17.6	17.5	18.6
RSE1	South-east boundary	19.5	19.3	22.8	22.5
RSE2	South-east boundary	22.7	23.4	34.1	34.6
RSE3	South-east boundary	7.7	8.1	14.9	15.5
RW1	West boundary	16.7	18.2	19.6	21.0
RW2	West boundary	17.4	18.9	21.3	22.7
RW3	West boundary	10.5	11.7	10.5	11.7

[1] Noise level contribution due to the phase-1 expansion noise sources.
[2] Cumulative noise level from the current and phase-1 expansion noise sources.

Table 4-3: Estimated Noise Levels at Receptors Along Site Boundaries.

5. IMPACT ASSESSMENT

5.1. General

The proposal is for the development of an expansion to the existing open pit and new plant. A worst case scenario is considered, i.e. that the open pit operations at surface level at the SK4 site and the new ore sorter and acid plant are the primary noise sources, that the primary noise sources are positioned as per the current plan, that there is a continuous cycle of noise from such equipment, and that the emitted noise is the maximum level measured over a representative period from that equipment.

5.2. Continuous Equivalent Noise Levels And Individual Noise Events

This report is an overall assessment designed to predict the collective response of a noise-exposed population and therefore the impact the operation is likely to have on them, and is based on measured and predicted equivalent continuous noise levels according to SANS 10103. Even if the noise impact is assessed as NONE, or VERY LOW, i.e. where a person with normal hearing will not be able to detect the predicted increase in the equivalent noise level, it will be possible to detect and distinguish individual noise events, e.g. when the a relatively noisy operation exceeds the momentary background noise level.

5.3. Existing Ambient Noise Levels At The Site

The above ambient $L_{Aeq,I}$ and background noise measurements agree well with the values recommended as the highest acceptable for rural districts according to the relevant section (Table 2 above) of SANS 10103:2004 (see Ref. 1) as follows:

Type of District	Daytime	Night-time
Rural	45	35

In view of the very consistent noise measurements obtained from around the concession area, these recommended values traceable to SANS ((45 dB(A) during daytime (06:00 to 22:00) and 35 dB(A) during night-time (22:00 to 06:00)) were used in the assessments which follow.

5.4. Predicted Impact Of General Site Operation Noise

5.4.1. The Active Bench

The two continuously noisy processes within the pit are the drilling and the loading processes. The combination of both these sources at similar distances from the assessment position is the worst case. This gives a predicted value of 87.7 dB(A) at 30m. The worst case is the early surface preparation activity when no significant screening from the pit wall will be available In the worst case, as described above, with no mitigating measures, and using the limit levels in 5.3. above, the daytime impact will be NONE beyond a distance of 4000m (13000m at night) from the active bench and LOW at 2240m (7000m at night) from the bench. There are no dwellings with line of sight to the mine workings indicated within this.

Exceedance dB	Noise Impact	Distance - day	Distance – night
0	None	4000m	13000m
3	Very low	2800m	8880m
3 ≤ 5	Low	2240m	7000m
5 ≤ 7	Moderate	1760m	5600m
7 ≤ 10	High	1280m	4000m
10 ≤ 15	Very high	720m	2240m

Table 5-1: Distances from the screened active bench or treatment plant for a certain response intensity and noise impact for various increases over the ambient daytime and night-time noise

5.4.2. The Acid Plant

Current design information for the acid plant indicates that noise levels will be significantly (14dB) lower than surface mining. It is therefore not a significant contributor to the total mine noise level until the operation moves into the pit below the surface.

5.4.3. The Ore Sorter

Current measured information for the ore sorter indicates that noise levels due to this source will be approximately the same as for the surface operation above and that, without mitigation, it will become the dominant noise source as the SK4 operation moves into the pit below the surface.

5.5. Conclusions

The worst case is the early surface preparation activity when no significant screening from the pit wall will be available In the worst case, as described above, with no mitigating measures, and using the limit levels in 5.3. above, the daytime impact will be NONE beyond a distance of 4000m (13000m at night) from the active bench and LOW at 2240m (5600m at night) from the bench. There are no dwellings with direct line of sight indicated within this distance.

5.6. Predicted Response To Blasting Operations

5.6.1 Effects Of Noise And Vibration On Humans

The nature and magnitude of the response to noise from blasting operations will depend critically on the blasting regime chosen, the nature of the rock to be blasted, the size and depth of the charge, the type of explosive, the local topography, and the detonation sequencing. As mentioned in section 2.7. above, there are at present no reliable national or international guidelines to accurately predict human or livestock response to blast noise. The closest habitations around the site are at distances of approximately 6km from the nearest point of blasting.

Neither the air blast nor the ground vibration are likely, in the author's experience, to have any damaging effect on humans, livestock, wildlife, or buildings in the vicinity, if they are designed and carried out with due regard to normal good blasting practice and with the desire to obtain cost-effective results in operational terms. However, both air blast and ground vibration can give rise to secondary noise in a building, such as the rattling of windows and other loose objects in a state of neutral equilibrium, and this is often interpreted as a far more serious occurrence than it really is. An additional complication is that the blast will in general contain frequencies below those which can be heard by the human ear i.e. below 20Hz. These low frequencies also contain sufficient energy to give rise to secondary noise, just as with ground vibration, making it characteristically difficult to differentiate between airborne blast and groundborne vibration, and the secondary effects of both.

Humans are extremely sensitive to vibration and can detect levels of ground vibration of less than 0.1 mm/s, which is less than 1/100th of the levels which could cause even minor cosmetic damage to a building. Complaints and annoyance regarding ground vibration are therefore much more likely to be determined by human perception than by noticing minor structural damage. However, these effects, and the startling effect of sudden impulses of both sound and vibration are often perceived as intrusion of privacy and could be a source of considerable annoyance to the local community. For this reason, and because of the absence of information on either the likely community response to blast noise or the likely levels of blast overpressure or audible noise, the noise impact should be considered MODERATE. However, previous notification of blasting activities at predetermined times on stated days, and careful design of the blasting regime to reduce the levels of both airborne blast noise and ground borne vibration will contribute significantly to the minimisation of the overall impact of blasting on the surrounding community.

Mitigation:

1. Calculating the charge size to keep air blast and ground vibration levels below pre-determined acceptable values.
2. Designing the blast regime and timing to optimise rock fragmentation and movement and minimize airblast effects and explosive use.
3. Correct stemming of blastholes, i.e. the filling of a suitable length of blasthole above the explosive charge with material of the correct type to minimize airblast, prevent the formation of flyrock and maximize the rock fragmentation.
4. Monitoring blast, ground vibration and human response to ensure accepted levels are in fact acceptable and are being adhered to, and to modify the blasting regime as appropriate.
5. Pre-notification of affected persons of the intention to blast and the time of blast, preferably at the same time of day and day of the week to remove the element of surprise.

5.6.2 Effect Of Vibration On Surrounding Structures.

There is wide agreement in the industry that the Peak Particle Velocity (PPV) is the parameter which best correlates with observed damage caused by vibration, and is widely applied in assessments. The first observable damage to structures, the forming of hairline cracks in plaster, begins at a PPV of about 25mm/s. The US Bureau of Mines recommends twice this value, 50mm/s, as the limit for residential property. Minor structural damage can occur to traditional masonry structures at values in excess of 100mm/s, and serious damage occurs at values in excess of

200mm/s, according to a range of authors (see ref. 14). Effects on temporary structures are likely to occur at values which are lower than for masonry structures, though the high variability in the type and construction quality of such structures renders reliable prediction of these values impossible.

For a surface blast, the relationship between the Peak Particle Velocity (**C**), the distance from the explosion (**R**), and the mass of the explosive (**W**), can be simply expressed (ref. 10) as follows:

$$\mathbf{C} = \mathbf{a}\left[\frac{\mathbf{R}}{\sqrt{\mathbf{W}}}\right]^{-b}$$

where **C** is the PPV in mm/s

R is the distance of the monitoring position from the explosion in meters.

W is the mass of the explosive charge in Kg.

a is a site-specific constant expressing the efficiency of excitation of the ground by a given charge, and depends on local geology, explosive coupling efficiency, resonance effects, ground condition and water content.

b is a site-specific constant expressing the attenuation of the PPV with distance.

The above equation enables the size of the charge to be determined so that the PPV at a specified distance can be kept below a predefined limit. The constants **a** and **b** are determined empirically by a small number of test blasts before the commencement of operational blasting. Vibration levels at a sensitive engineering structure have been successfully managed (ref. 10) by using this technique at an open pit mine expansion. This mine expansion is said to be similar in structure and operating procedures to the proposed mine expansion, so results from that investigation (ref. 10), especially the values of the constants **a** and **b** should be broadly applicable to the conditions at. It is recommended in the first instance that that, when known, the planned explosive charge sizes be entered into this equation to check whether there is any possibility that the PPV at sensitive structures could exceed the accepted limit for cosmetic damage. If this proves to be the case, then a set of test blasts should be considered before operations begin to determined the constants **a** and **b** specifically for the site, and calculate actual PPVs at sensitive buildings. Because ground vibration due to blasting can be controlled by competent blast design and because the levels likely to cause even cosmetic structural damage at the nearest farmhouses, the vibration impact is considered VERY LOW.

Mitigation:

As for section 3.6.1 above, plus the following

1. Monitoring of sensitive structures for signs of attributable damage.
2. Vibration monitoring of the structure to ascertain actual vibration levels

5.6.3 Effect Of Noise, Blast Noise, and Vibration On Livestock and Wildlife

Very little information exists on the response of livestock, or indeed wildlife, to noise, blast noise, and ground vibration. (refs. 9, 16, 17, 18). There is no evidence whether or not livestock will be adversely affected by the noise and vibration of operations and how, or how much, they will be affected. The impact on livestock of operating noise and ground vibration is considered VERY LOW, whereas the impact of blast noise, because its occurrence is sudden and unpredictable and animals startle in reaction to sudden noises such as blast and sonic boom, on which much work was done with the advent of supersonic transports in the 1970s, is probably MODERATE.

Mitigation:

As for section 3.6.1 above, plus the following:

Regular monitoring of the exposed livestock to ascertain if there are any adverse reactions.

5.7. Noise Management and Mitigation Options

Mitigation Measures:

1. <u>Maintenance of equipment and operational procedures:</u> Proper design and maintenance of silencers on diesel-powered equipment, systematic maintenance of all forms of equipment, training of personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.
2. <u>Placement of material stockpiles:</u> Where possible material stockpiles should be placed so as to protect the boundaries from noise from individual operations and

especially from haul roads, which for greatest effect should be placed directly behind them. If a levee is constructed, it should be of such a height as to effectively act as a noise barrier, if line of sight calculations show this to be practicable. In particular, the erection of suitable earth berms around fixed plant such as compressors can significantly reduce the noise by up to 15dB.

3. Equipment noise audits: Standardised noise measurements should be carried out on individual equipment at the delivery to site to construct a reference data-base and regular checks carried out to ensure that equipment is not deteriorating and to detect increases which could lead to increase in the noise impact over time and increased complaints.
4. Environmental noise monitoring: Should be carried out at regularly to detect deviations from predicted noise levels and enable corrective measures to be taken where warranted.

Noise management and mitigation options

Phase	**Impact: Noise**						
	Nature	**Extent**	**Duration**	**Intensity**	**Probability**	**Significance**	
						WM	**WOM**
Construction	Noise	Site local	Short term	Low Negative	Probable	None	V Low
Operation	Noise	Site local	Long term	Low Negative	Probable	None	Low
Decommissioning	Noise	Site local	Short term	Low Negative	Probable	None	V Low
Residual	None	n/a	n/a	n/a	n/a	n/a	n/a
Latent	None	n/a	n/a	n/a	n/a	n/a	n/a

Table 5-2. Summary of noise impacts at 2240m during daytime and 7000m at night

WM=With mitigation, WOM=Without mitigation

Source	**Remedial measures**
Mobile equipment noise	Select vehicle routes carefully by means of internalising the roads Fit efficient silencers and enclose engine compartments Damp mechanical vibrations Erect bank, screen or barrier along haul roads where feasible
Fixed plant noise	Reduce noise at source damping acoustic treatment, etc. Isolate source by enclosure in acoustic building, room, etc. Carefully select fixed plant site for remoteness from sensitive areas Raise barriers or berms around noisy equipment

Table 5-3. Summary of major sources of noise associated with mining operations, and the possible general remedial measures

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